CLAIMS

1) A new type of focal plane array — multicycle integration focal plane array (MIFPA), linear or area, which, unlike the existing FPA of single-cycle integration, utilizes three additional MOS switches (M1, M2, and M3 of fig. 1) and one additional capacitance (C1 of fig. 1) for each pixel to perform on-chip multicycle integration.

2) Applications of MIFPA — to detect extremely weak signals for imaging, spectroscopy, and spectroscopic imaging.

3) Three operational modes of MIFPA — lock-in (LI-), gated (G-), and gated lock-in (GLI-) modes.

4) A new type of focal plane array — lock-in multicycle integration focal plane array (LI-MIFPA), linear or area, which possesses the following features:

a) it uses an active or passive modulator to modulate the signal;

b) it does not modulate dark and/or background current;

c) it uses a correlated multicycle integrator for each pixel, so that the signal current is accumulated while the background and/or dark current is cancelled;

d) the integration time of the LI-MIFPA can be many orders longer than that of the existing FPA technology;

e) therefore, the signal to noise ratio, dynamic range, and low frequency or $1/f$ noise of the LI-MIFPA can be improved by many orders in comparison with the existing FPA technology.

5) Applications of LI-MIFPA — to detect extremely weak signals for imaging, spectroscopy, and spectroscopic imaging.

6) A new type of focal plane array — gated multicycle integration focal plane array (G-MIFPA), linear or area, which has the same multicycle correlated integrator for each pixel as the LI-MIFPA, is programmed to operate in the gated mode, and possesses the following features:

a) it uses a pulsed light source to generate a repetitive signal (as in the case of IR fluorescence spectroscopy using nano-second pulse laser excitation);

b) the G-MIFPA is used when the number of integrated signal electrons is many orders smaller than that of the background and/or dark current electrons $\alpha I_s << I_b$, but αI_s is not $<< I_b$;

c) in G-MIFPA the direction of integration of the correlated multicycle integrator does not change as in the LI-MIPFA; The integrator is turned on by a trigger signal from the gate control circuit to integrate the signal photocurrent pulse, and turned off after a certain increment of time;

d) the integration time of the G-MIFPA can be many orders longer than that of the existing FPA technology;

e) therefore, the signal to noise ratio, dynamic range, and low frequency or $1/f$ noise of the G-MIFPA can be improved by many orders in comparison with the existing FPA technology.

7) Applications of G-MIFPA — to detect extremely weak signals for imaging, spectroscopy, and spectroscopic imaging.

8) A new type of focal plane array — gated lock-in multicycle integration focal plane array (GLI-MIFPA), linear or area, which has the same multicycle correlated integrator for each pixel as the LI-MIFPA, is programmed to operate in the gated lock-in mode, and possesses the following features:

a) it uses a pulsed light source to generate a repetitive signal (as in the case of LWIR spectroscopy using nano-second pulse laser excitation);

b) the GLI-MIFPA is used when the signal is not only short, but is also associated with a much stronger background ($\alpha << 1, I_s << I_b$);

c) in GLI-MIFPA, the correlated multicycle integrator goes through three phases (Fig. 5.b). In $\phi 1$, which lasts $\alpha\tau$, the integrator integrates both the signal pulse and strong background currents. In $\phi 2$, which has the same duration as $\phi 1$, the integrator reverses its direction of integration, and cancels the background of $\phi 1$. In $\phi 3$, which lasts much longer than $\phi 1$ or $\phi 2$, the integrator is turned off.

d) the GLI-MIFPA combines the advantage of the G-mode — reduction of the on-time of the integrator to increase the integration time — and that of the LI mode — cancellation of background to increase the integration time;

e) therefore, the signal to noise ratio, dynamic range, and low frequency or $1/f$ noise of the G-MIFPA can be improved by many orders in comparison with the existing FPA technology.

9) Applications of GLI-MIFPA — to detect extremely weak signals for imaging, spectroscopy, and spectroscopic imaging.

10) A new device — correlated multicycle integrator (comprising of one operational amplifier or source follower and four MOS switches), which can be programmed to control the MIFPA to operate in lock-in (LI-), gated (G-), or gated lock-in (GLI) mode.